In-Process Measurement of Kinematic Viscosity

Matthias Acksel, Head of Development Process Analyser Technology, BARTEC BENKE GmbH,
Borsigstraße 10, D-21465 Reinbek, Germany Phone: +49 40 72703 272 Fax: +49 40 72703 363 E-mail: matthias.acksel@bartec-benke.de

Viscosity is an important product property and a decisive measurement parameter in the production and quality supervision of petrochemical end products such as heating oils and lubricants and of their feedstocks. For the control of production processes, efficient and robust process analysers are required to measure the viscosities of such liquids. As to the determination method for viscosity, the primary norms for these petrochemical products (e.g. heating oil DIN 51603, diesel DIN EN 590, marine fuels ISO 8217) refer to standards describing capillary viscometers with a high temperature precision for the measurement of kinematic viscosity (e.g. ASTM D 445, ISO 3104 and DIN 51562-1). In order to achieve comparability, capillary viscometers are also applied in the production process.

For measurements in the laboratory, calibrated glass capillaries are used: they measure the passage time of a liquid volume under the impact of gravity. The value of kinematic viscosity results from the product of the measured passage time and the device constant of the capillary: $\nu = C * t$. As viscosity is highly dependent on the temperature, the temperature of the liquid during the measurement has to be regulated precisely and kept on a constant level (0.02 K in accordance with ASTM D 445). For a continuous determination of the viscosity of a liquid during the production process, the liquid is conducted in viscometers through a capillary. From the mass flow rate through the capillary and from the pressure dropping over the length of the capillary, the current value of the kinematic viscosity of the liquid is ascertained by applying the law of Hagen-Poiseuille.

Most of the capillary viscometers for process applications available in the market today ascertain the value of dynamic viscosity. They stabilise the temperature of the liquid in the capillary by means of a temperature-regulated oil bath with a circulation pump. This solution is very complex and not without problems: the temperature precision and a homogeneous temperature distribution are often not achieved, temperature stabilisation times after switching on or after switching over to another product flow are long, regular maintenance works including the discharge of thermal oil are time-consuming, only to mention some of the disadvantages.

In the development of the Viscosity Process Analyser VISC-4 made by BARTEC BENKE, special attention was paid to the solution of known problems of the online measurement during the production process and to the requirements of the standards ASTM D 445 and ISO 3104.

The application of a high-precision temperature measurement and regulation made an oil bath as well as pumps completely superfluous. What is also new is the continuous measurement of the mass flow through the capillary: the VISC-4 continuously determines the kinematic viscosity, which compares directly with laboratory results without any need for conversions. At the same time the density of the liquid is also measured and with the directly measured kinematic viscosity it can be used to calculate and display the dynamic viscosity. The dynamic viscosity results from the product of the kinematic viscosity and the associated density under measurement temperature: $\eta = \nu * \rho$. Under certain conditions, the standards prescribe that it is necessary to correct the measured values by applying the so-called Hagenbach correction in order to compensate for measurement errors arising from inlet and outlet losses. This measurement error can be caused, among other things, by insufficient inlet and outlet sections of the capillary. For the VISC-4, the necessity of such a correction of the measurement value is eliminated due to suitable constructive measures, also in view of the inlet and outlet sections, which is required for applying the law of Hagen-Poiseuille.

The highly complex sample preparation systems for viscosity measurements are constructed in an application-specific manner. Implemented special functions such as the automatic rinsing and venting procedure offer solutions for difficult applications. The VISC-4 also supports the automatic power switching for the measurement of two products flows under different measurement temperatures with minimised temperature stabilisation times.

The touch-screen of the VISC-4 offers a clear visualisation of data and measurement results and allows a comfortable on-site control and configuration of the analyser. For the control of the VISC-4 by superordinate systems and for data transmission, digital and analog signals and a modbus interface are available. Remote maintenance interfaces (e.g. network, modem/ISDN) allow a comfortable access to the analyser for the purposes of maintenance, configuration and system diagnosis. This interface also makes possible a worldwide and quick support and service provided by BARTEC BENKE.

The VISC-4 is available in several variants for different measurement ranges and temperature ranges: depending on the respective ranges and their combinations, kinematic viscosities from 0.7 cSt to 500 cSt can be measured at temperatures from 20°C to 100°C. The VISC-4 is ATEX-approved for use in zone 1 of hazardous areas.

The continuous display of the kinematic viscosity, the high temperature precision and the minimised maintenance expenditure show the high process efficiency of the Viscosity Process Analyser VISC-4, which has been confirmed by the field tests that have been carried through.

Summarising Overview of the most Outstanding Unique Characteristics:

The direct and continuous measurement of the kinematic viscosity allows the direct comparability with laboratory results without any need for conversion

Integral measurement of the density and calculation and display of the dynamic viscosity $\eta = \nu * \rho$

An innovative temperature control system and insulating system allows to do without a classical thermal oil bath and pumps and significantly minimises the maintenance expenditure

High-resolution temperature measurements and high-precision heating regulations allow to adhere to the requirements on the temperature stability (0.02 K) defined in the underlying standards (ASTM D 445, DIN EN ISO 3104)

The necessity of the Hagenbach correction is eliminated through suitable construction, therefore the direct application of the law of Hagen-Poiseuille is possible.